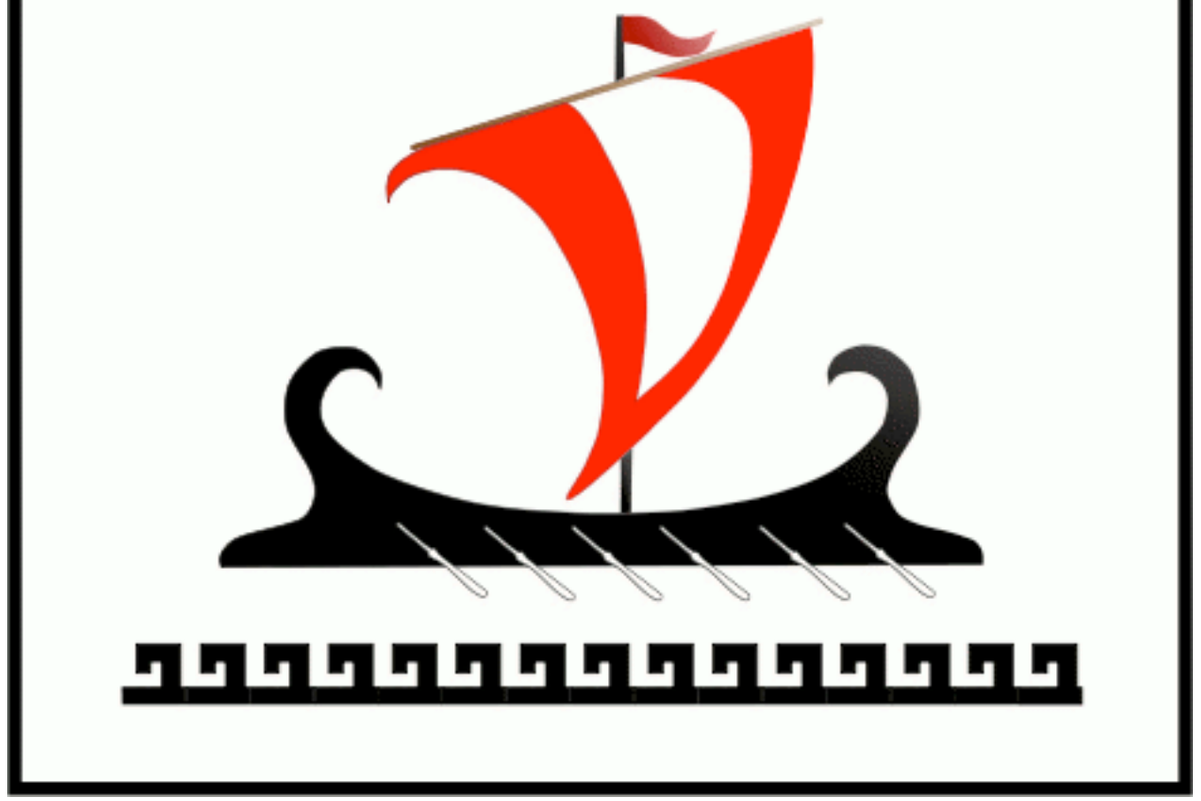
ArgoNeuT



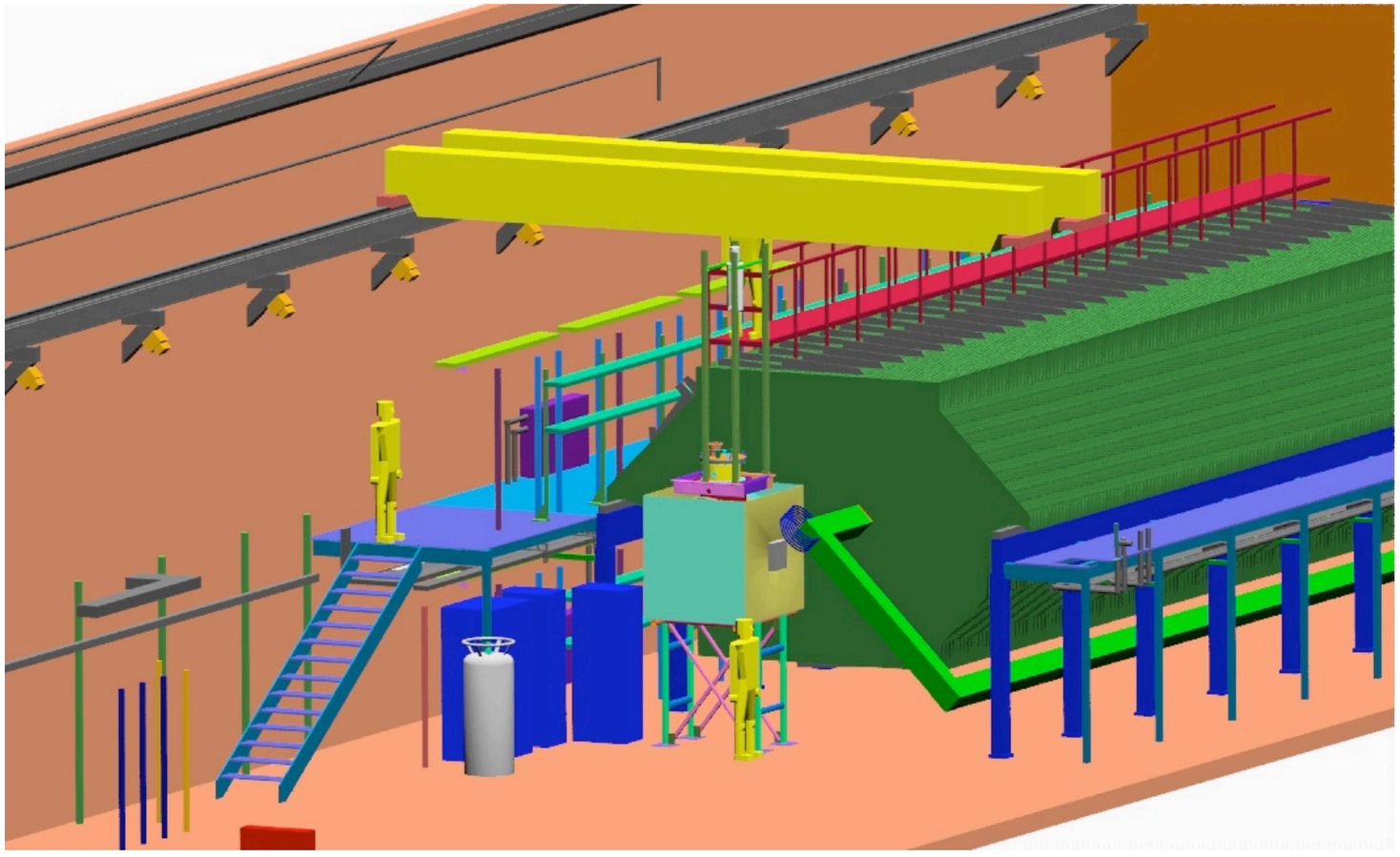
MINOS Collaboration Meeting

Mitch Soderberg
Yale University

12/16/2008

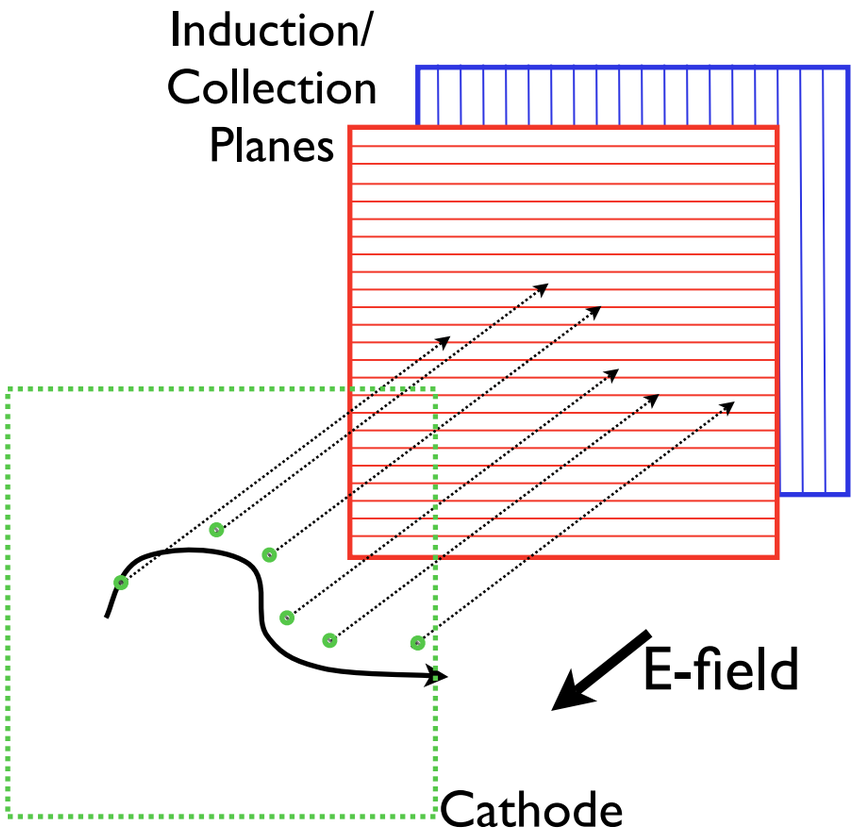
Introduction

- ArgoNeuT (a.k.a. - test experiment T962) is a ~175 liter Liquid Argon Time Projection Chamber
- Will sit in front of MINOS near detector in NuMI beamline. Use MINOS as a muon range stack.
- Jointly funded by NSF/DOE.
- Goals:
  - Gain experience building/running LArTPCs.
  - Accumulate a sample of neutrino events.
  - Confront all aspects of underground running and safety.
  - Develop simulation of LArTPCs and compare with data.

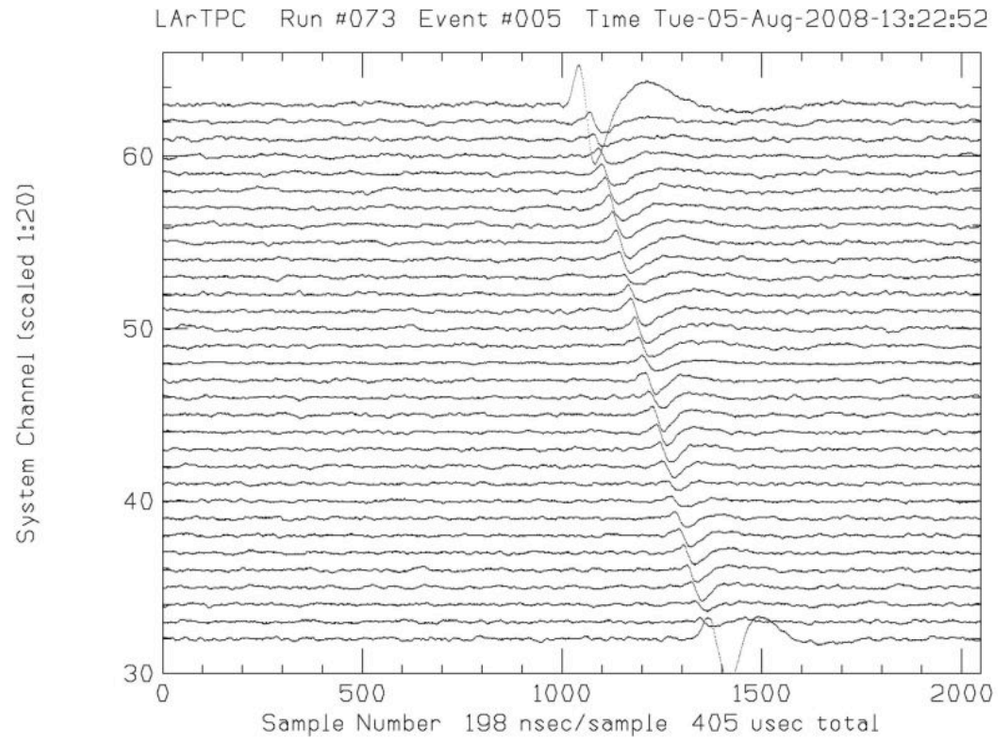


Liquid Argon TPC: Basic Idea

- Interactions inside TPC produce ionization particles that drift along electric field lines to readout planes.
- Scintillation light also present, can be collected by PMTs and triggered on.
- Knowledge of drift speed, T_0 of events, and physical location of wires, can be used to reconstruct interaction.
- Argon is an excellent medium for this technique due to its inert properties.
- Argon must be very clean (ppt) to allow drift over several meters without large attenuation.
- Excellent particle ID capability using dE/dx tag.



Train of pulses, with time offsets due to different drift lengths.



Collaboration

F. Cavanna
University of L'Aquila

B. Baller, C. James, G. Rameika, B. Rebel
Fermi National Accelerator Laboratory

M. Antonello, R. Dimaggio, O. Palamara
Gran Sasso National Laboratory

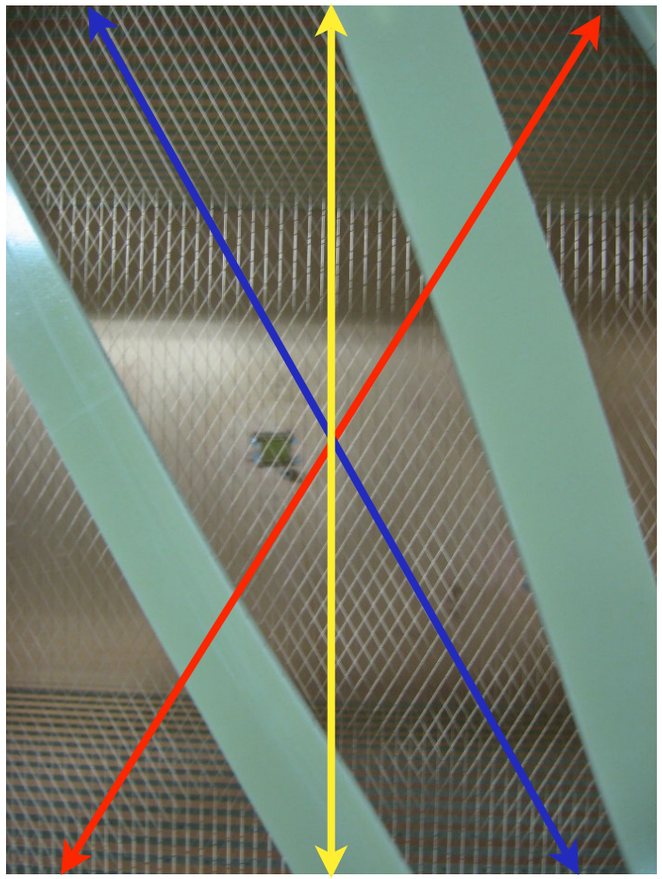
C. Bromberg, D. Edmunds, P. Laurens, B. Page
Michigan State University

S. Kopp, K. Lang
The University of Texas at Austin

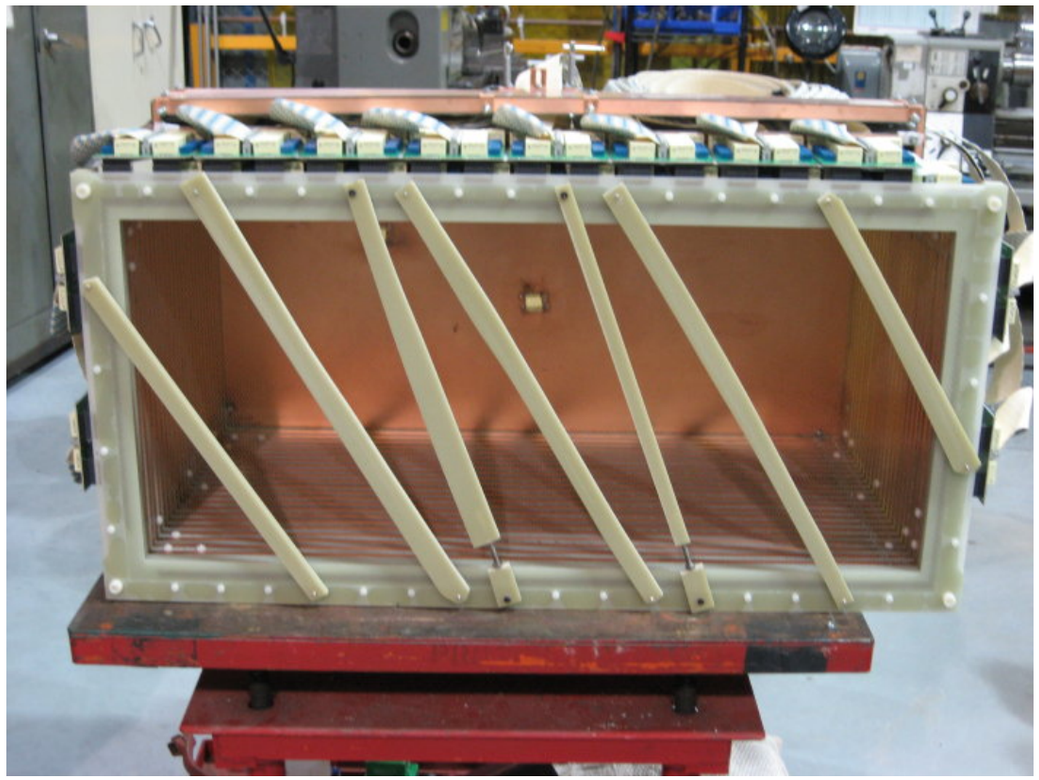
C. Anderson, B. Fleming*, S. Linden, M. Soderberg, J. Spitz
Yale University

ArgoNeuT Detector

- 175 liter active volume in TPC
- 480 channels of electronic readout built by MSU.
- Collection, Induction2, Induction1 planes. Wires at ±60°
- 4mm wire pitch, 4mm plane spacing.
- 500V/cm electric field, Max. drift of ~50cm.
- Purity monitor for measuring impurities in liquid argon.



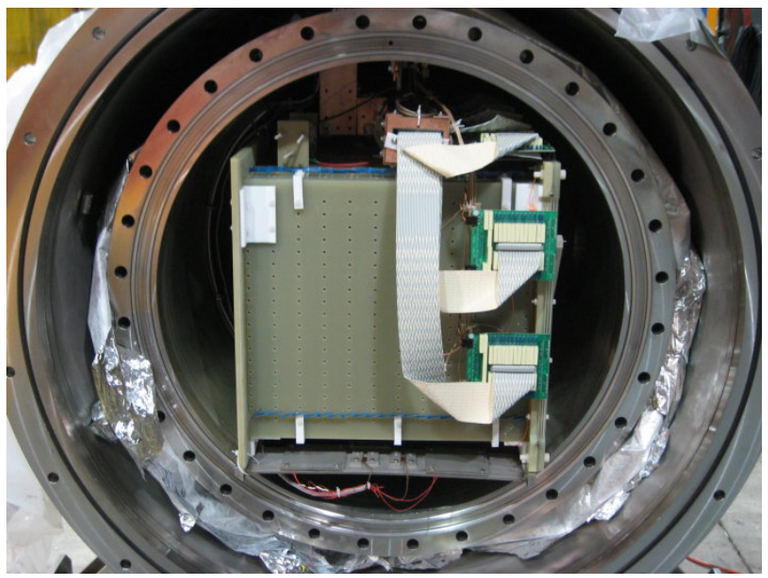
Wire Orientations



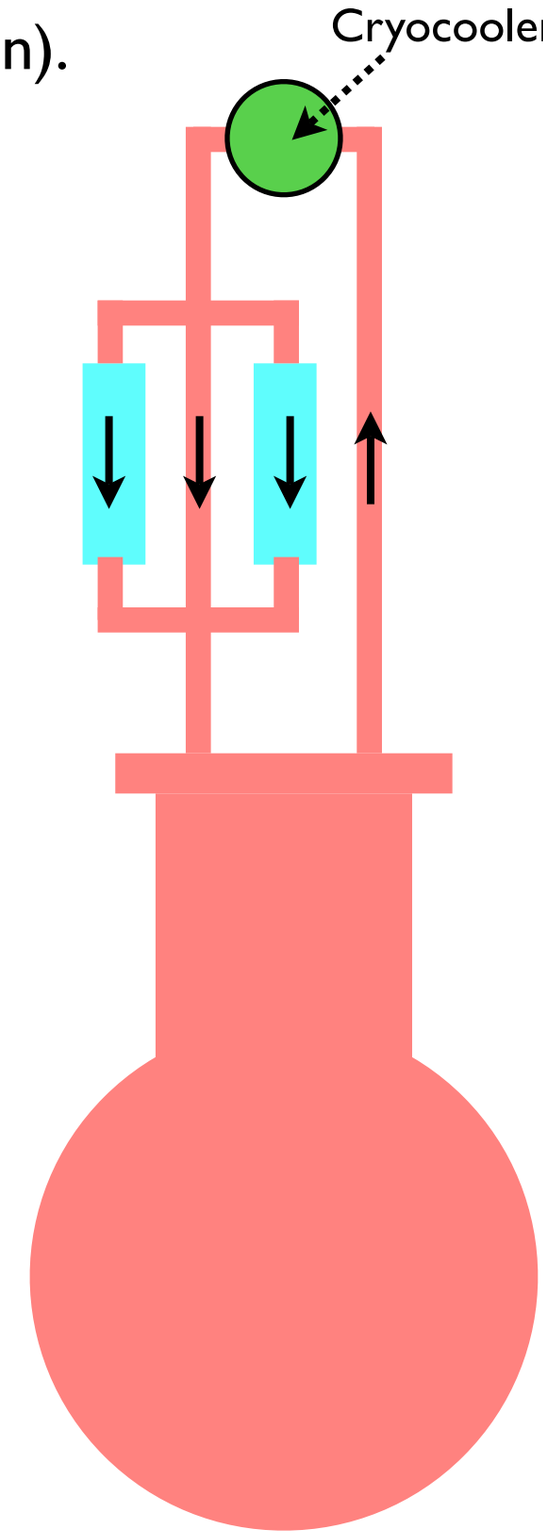
TPC with readout cables

ArgoNeuT Detector

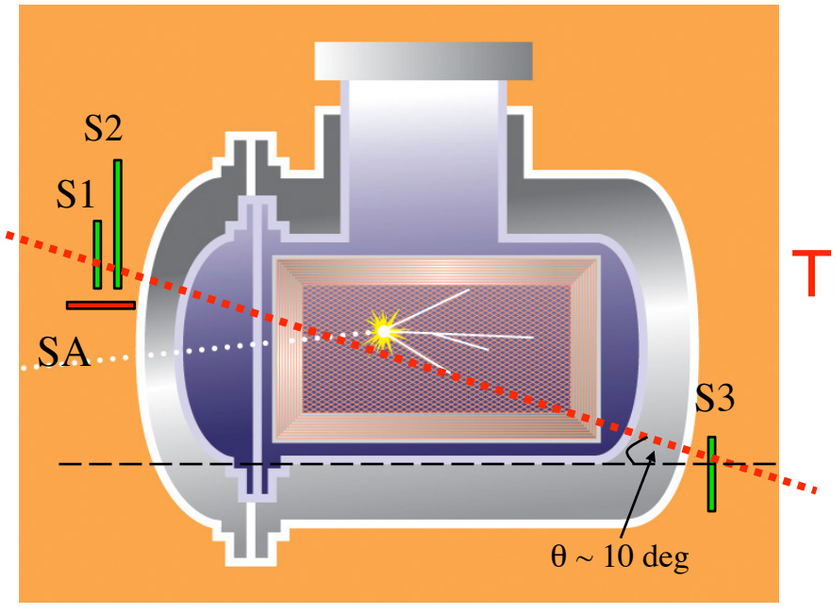
- Self-contained cryogenic system (*i*.e. - maintain constant Argon supply).
- Recirculate argon through filters to remove impurities (e.g. - Oxygen).
- Cryocooler used to condense boil-off gas.
- Vacuum-jacketed cryostats/pipes for insulation.
- Multiple relief paths to achieve safe running.



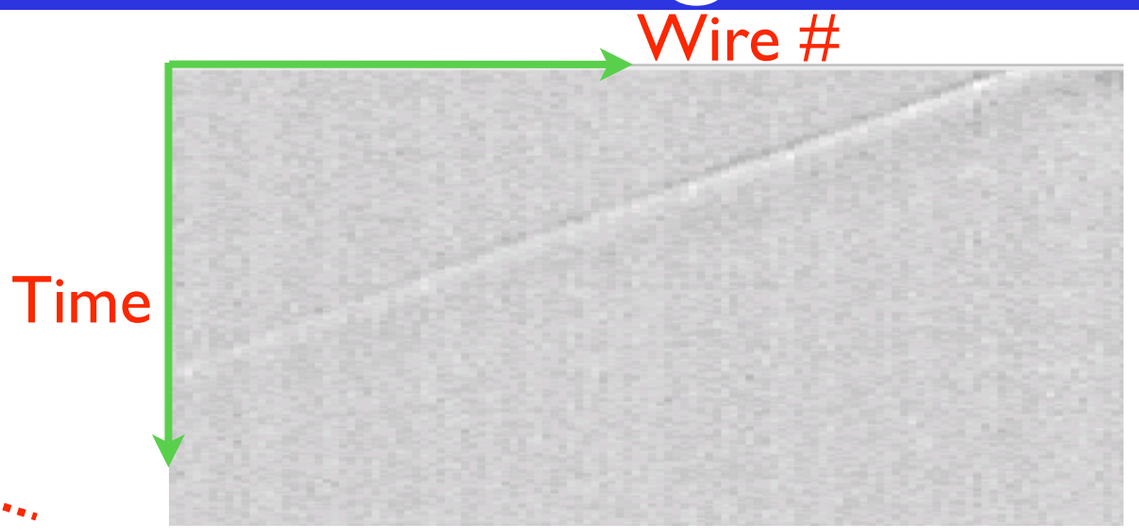
ArgoNeuT at PAB.



Commissioning Events

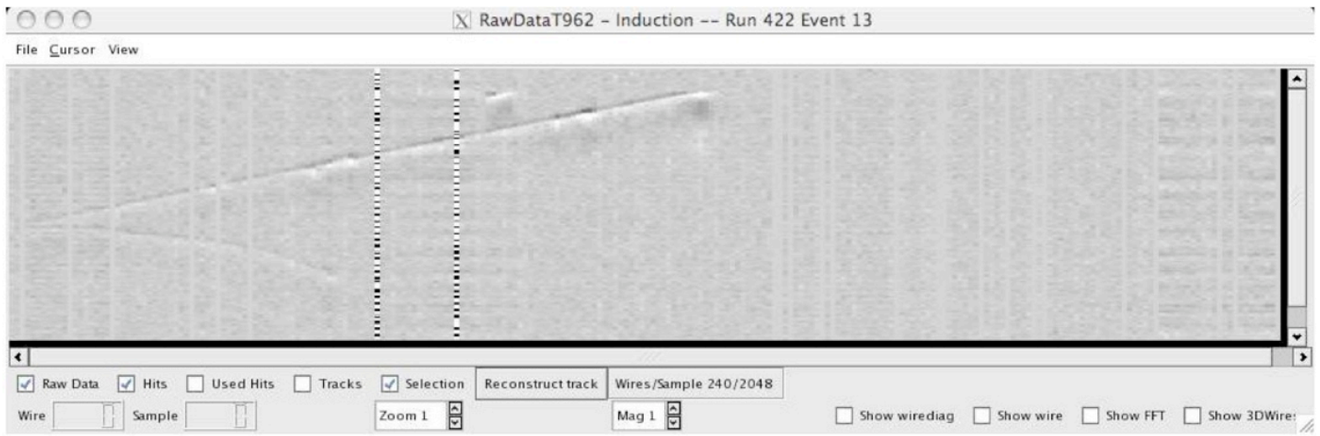


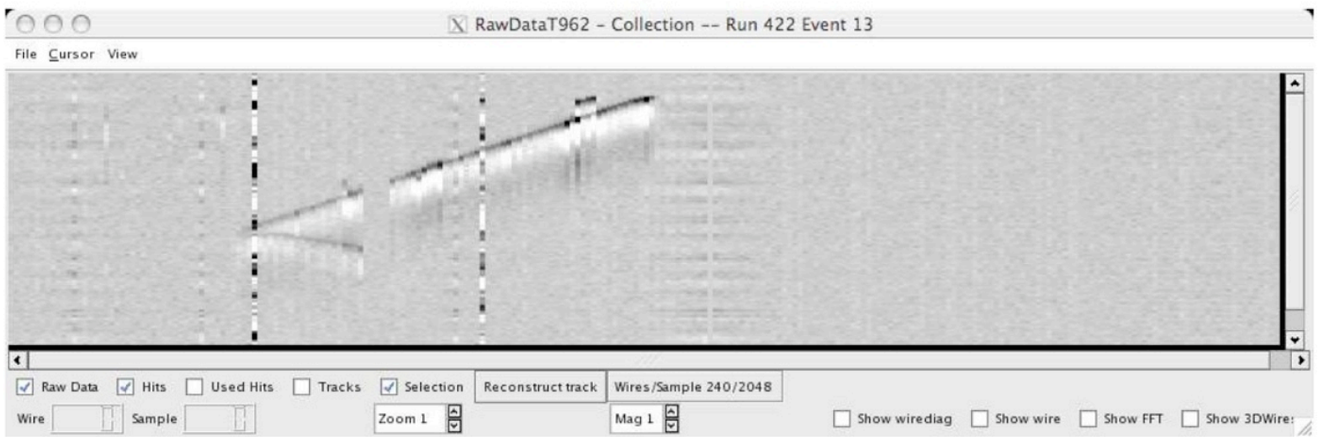
Cosmic Trigger for Commissioning



Induction View of Cosmic muon event

Noisy channels due to readout cables getting damaged during commissioning install. All cables have since been replaced.



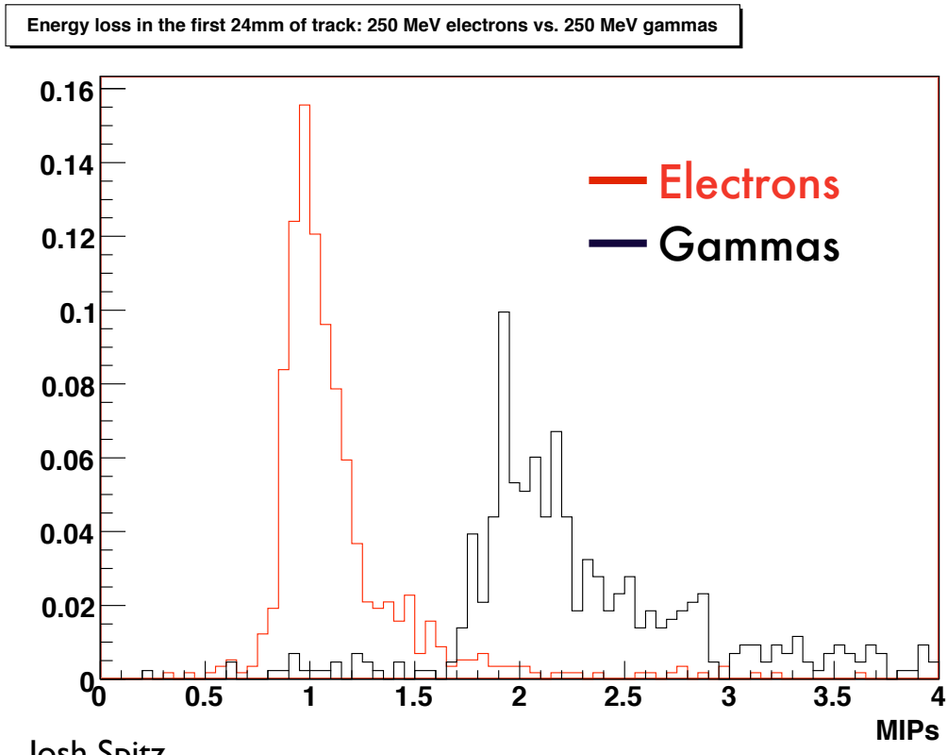


Collection/Induction views of Commissioning Event

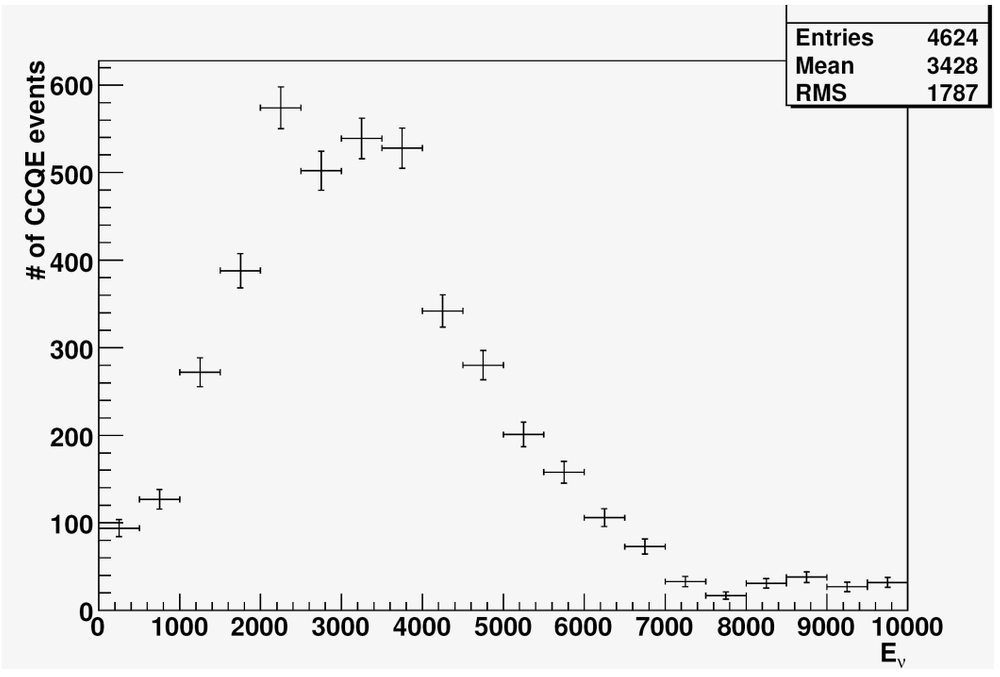
Physics Goals

Event Type	# in ArgoNeuT/day (0.8×10^{17})
ν_μ CC	160
$\overline{\nu_\mu}$ CC	14
ν_e CC	3
NC	54
Total	231

Expected event rate



Josh Spitz



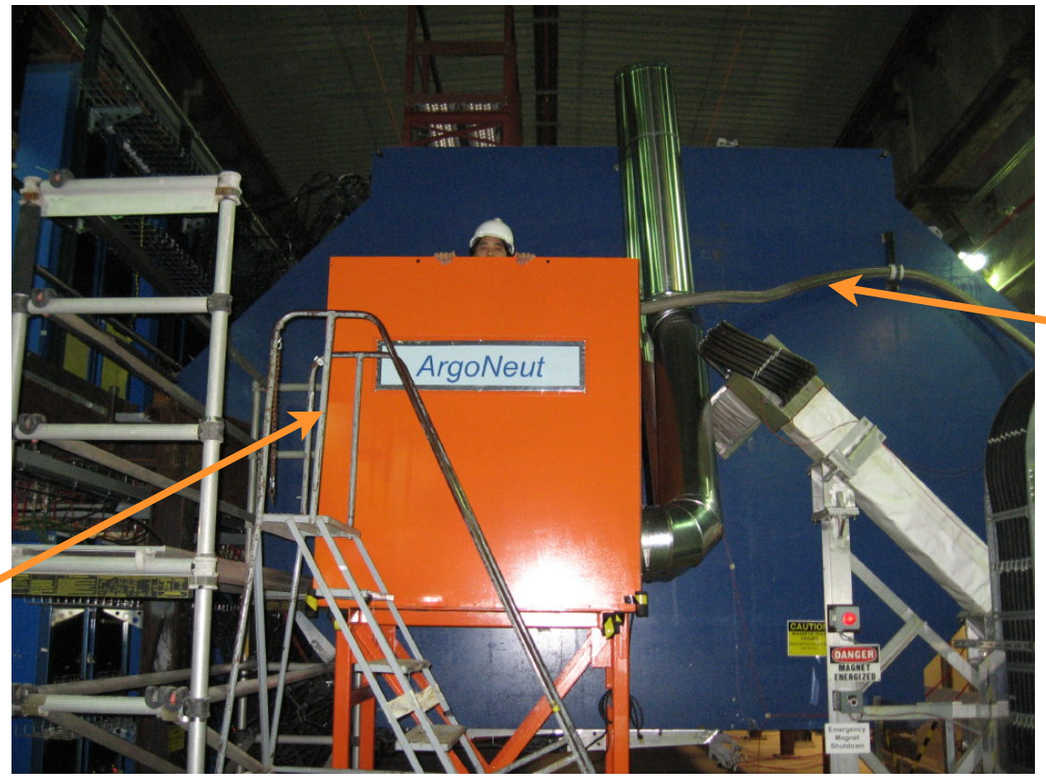
Josh Spitz

- Electron/gamma separation - Study capability of LArTPCs using dE/dx tag.
- Collect large sample of CCQE events, measure cross-section
- Develop realistic simulation of LArTPCs
- Develop reconstruction algorithms.

Underground Operation

Many safety issues addressed to prepare for move underground and maintain ODH-0 rating of tunnel:

- ArgoNeuT sits in a mixing bathtub, which acts as tertiary containment in case both cryostats fail.
- Relief piping is routed to vent line (runs up and out shaft), to ensure no argon released in tunnel.
- 2 ODH monitors to alarm if leak is detected.
- Slow control system in tunnel, and online, to alert of any ODH hazards.

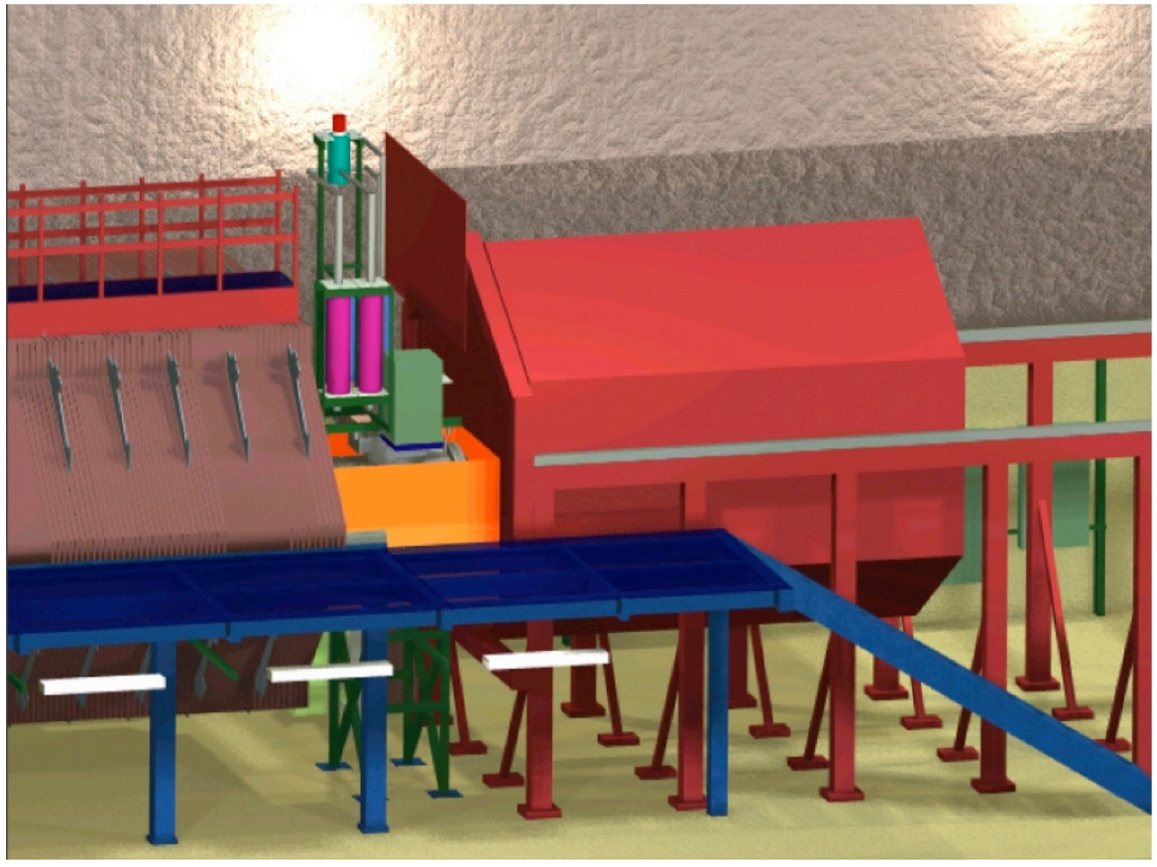


Bathtub

Vent Line

Status

- Re-assembly of detector above ground, after numerous upgrades, almost complete.
- Plan to move cryostat underground and into bathtub in next week, or early Jan.
- Installation of plumbing, cabling, etc... will take another few weeks.
- During normal running, work underground will involve:
  - Swapping of filters (every ~2 weeks?)
    - Access to cryocooler valves from top of MINOS catwalk will be required.
  - Argon purity checks (several times/week....hopefully can be automated).
  - Visual inspection of pumps/compressors/gauges/etc... (several times/week).
- Plan is to run for at least 6 months. Move out before Minerva begins final installation.



Conclusion

- ArgoNeuT is an important milestone in the U.S. for LArTPC development.
- Real data/experience will be invaluable in substantiating the case for LArTPCs in the U.S.
- Collaboration with MINOS very important and appreciated ;-)
- Running very soon!

Back-Up Slide

Noble Liquids: Properties

- Ionization and scintillation light used for detection (transparency to own scintillation).
- Ionization electrons can be drifted over long distances in these liquids.
- Very good dielectric properties allow high-voltages in detector.
- Argon is cheap and easy to obtain (1% of atmosphere).

	Water	He	Ne	Ar	Kr	Xe
Boiling Point [K] @ 1atm	373	4.2	27.1	87.3	120.0	165.0
Density [g/cm^3]	1	0.125	1.2	1.4	2.4	3.0
Radiation Length [cm]	36.1	755.2	24.0	14.0	4.9	2.8
Scintillation [γ /MeV]	-	19,000	30,000	40,000	25,000	42,000
dE/dx [MeV/cm]	1.9		1.4	2.1	3.0	3.8
Scintillation λ [nm]		80	78	128	150	175

Liquid Argon Detectors appear scalable to large sizes!